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# Madhani et al.

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(54) ARTICULATED SURGICAL INSTRUMENT FOR PERFORMING MINIMALLY INVASIVE SURGERY WITH ENHANCED DEXTERITY AND SENSITIVITY

(71) Applicant: Intuitive Surgical Operations, Inc.,

Sunnyvale, CA (US)

(72) Inventors: Akhil J. Madhani, Glendale, CA (US);

J. Kenneth Salisbury, Mountain View,

CA (US)

(73) Assignee: Intuitive Surgical Operations, Inc.,

Sunnyvale, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this

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This patent is subject to a terminal dis-

claimer.

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# Related U.S. Application Data

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(58) Field of Classification Search

CPC ...... A61B 19/2203; A61B 19/22; A61B

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# (56) References Cited

# U.S. PATENT DOCUMENTS

1,620,828 A 3/1927 Molony 4,259,876 A 4/1981 Belyanin et al. (Continued)

#### FOREIGN PATENT DOCUMENTS

EP 0595291 A1 5/1994 JP S5537297 A 3/1980 (Continued)

#### OTHER PUBLICATIONS

Office Action mailed Sep. 1, 2014 for Japanese Application No. 20130027668 filed Feb. 15, 2013.

(Continued)

Primary Examiner — Julian W Woo

# (57) ABSTRACT

An articulated surgical instrument for enhancing the performance of minimally invasive surgical procedures. The instrument has a high degree of dexterity, low friction, low inertia and good force reflection. A unique cable and pulley drive system operates to reduce friction and enhance force reflection. A unique wrist mechanism operates to enhance surgical dexterity compared to standard laparoscopic instruments. The system is optimized to reduce the number of actuators required and thus produce a fully functional articulated surgical instrument of minimum size.

### 7 Claims, 8 Drawing Sheets

